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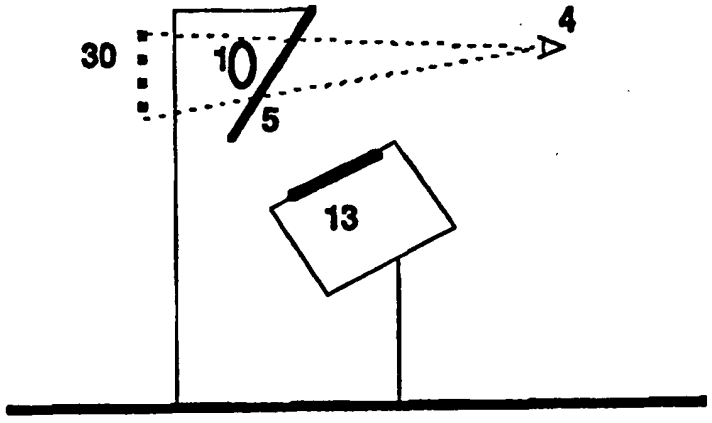
(54) Title: DEVICE AND METHOD FOR SUPERIMPOSING IMAGES IN A THREE-DIMENSIONAL SETTING WITHOUT USING LENSES

(57) Abstract

There is disclosed an arrangement producing superimposed images on a three-dimensional background incorporating a transparent surface which is partially mirrored to allow an undistorted view of one or more objects, holographic images or real images while also reflecting a background which will mask the view of the surroundings or reflectors and provide a three-dimensional setting for the images and real images. The two-way mirror can be laminated to make a protective layer to prevent vandalism of the reflectors or theft of the object. The angle of the two-way mirror is set to reflect a background so that any light from the area of the observer does not create any distractions or undesirable reflections. With the use of mechanical systems it is possible to select different real images and to control and manipulate the actual objects while viewing the real images. The position of the real image can be moved by moving the position of the display object or by changing the curvature of the reflectors in the optical system. With the use of position sensors the real images can act as control mechanisms to operate an interactive display which does not require physical contact with the control mechanisms.



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DEVICE AND METHOD FOR SUPERIMPOSING IMAGES IN A THREE-DIMENSIONAL SETTING WITHOUT USING LENSES

This invention relates to a device and method for displaying images of one or more objects or real images superimposed onto a three dimensional setting without the usage of lenses.

Methods have been developed for displaying a real image using lenses. These lenses have been combined with a two-way mirror between the viewer and the lenses to reflect a background for the real images. The result has been to achieve a real image superimposed onto a background. This approach has not succeeded in widespread usage because of the limitations in using lenses. Glass lenses are expensive in a small size and exorbitant in cost for large diameters. Plastic lenses are of poorer quality and still are too expensive for large displays. The usage of fresnel lenses can cut down the cost but does not provide an acceptable image quality. The fact that there has not been an acceptance of systems based on lenses suggests that this method for superimposing images onto a background is not viable.

The present invention is based on a different approach that achieves a high quality image superimposed onto a background or three dimensional setting. Since lenses are not used the liabilities of colour fringing, optical aberrations or soft focus are avoided. The basic method and all variations of the invention are based on the usage of a two way

mirror with the possible inclusion of reflectors or holographic film.

It is the two way mirror that is the key to superimposing the image of the object into a three dimensional setting. The reflected image of the background presents enough light to mask the surroundings of the object and any reflectors or holographic film used to create a real image. This method is far superior to the approach of using a scrim of transparent material between the viewer and the object as taught in US-5 257 130. The fabric of the scrim can partially obscure the optical system since the scrim is comprised of opaque threads woven in a fine mesh, however the fabric also partially obscures the object or real image. Furthermore, the scrim can be prone to becoming dirty or damaged by viewers.

A drawback of the usage of a scrim is that the real image is only viewed against the flat surface of the scrim. This limits the creative potential for the display of the three dimensional real image since it is not possible to display a three dimensional image in a natural setting that is itself three dimensional. In particular, it is not natural to have a three dimensional object suspended in front of a flat surface with no means for support.

With the display of objects for public viewing there is always the liability that a person will vandalise the display or steal the object. Placing a scrim between the real image and the object is a deterrent but does not provide a vandal-proof solution. By definition a scrim is a porous material that allows the passage of light through the open weave which would mean that the material could be easily cut to gain access to the optical system or the object.

There are many applications where it would be useful to be able to view a real image of an object in an isolated environment which might involve radioactive materials, poisonous gases or dangerous manufacturing processes. The approach of using a scrim would not give much protection since the scrim is porous and would allow air to pass through it. If a protective layer of glass was used in conjunction with the scrim it would introduce undesirable reflections and highlights which would interfere with the illusion because of the configuration of the display system using a scrim.

This invention provides for a device and method for displaying images of one or more objects or real images superimposed onto a three dimensional setting without the usage of lenses.

The invention comprises an arrangement for displaying objects, holographic images or real images of objects comprising objects, holographic film or an optical system for forming the real image, a two-way mirror through which the images are viewed and a background panel arrangement which is reflected to the viewing position by the two-way mirror so that the objects, holographic images or real images are seen from the viewing position against a reflection of the background. The two way mirror may be angled to reflect an image of a three dimensional setting which is designed to be relatively dark where the objects, holographic images or real images are to appear. The light on the background only needs to be bright enough to be more visible than the extraneous light on the surroundings or optical elements. To present the illusion, the objects, holographic film or objects within a real image optical system are illuminated and then viewed through the two way mirror. Since the two-way mirror does not obscure the image in the manner of a scrim or translucent material the images are clear and sharp.

Furthermore, the image of the reflected three dimensional setting is equally sharp. For the best results the light on the objects, holographic film or objects within a real image optical system is usually brighter than the light on the reflected background so that the light on the background is not noticeable where the objects, holographic images or real images are viewed.

The two-way mirror can be of glass, which may be laminated for added protection, or may be a partially mirrored transparent, unbreakable plastic. In cases where there is no requirement for protection of the objects or optical system the two way mirror may be a stretched film with a semi-reflective coating.

In the simplest arrangement of the invention, a view is displayed of a three dimensional background which is seen as a reflection in a two way mirror while an image of an object is viewed directly through the two way mirror. Since the object is seen to be closer to the viewer than the reflection of the background, the superimposed images create the illusion of a combined three dimensional scene. Since this is achieved without the usage of any lenses the cost is minimal and the installation of the display is simple. While arrangements using lenses have been restricted in size, this invention can be applied to large single user displays, exhibits for group viewing and full size theatres for audiences.

A variation on the invention is to use a sheet of holographic film to produce the three dimensional image to be superimposed into the three dimensional background. The background reflected in the two way mirror can take the attention away from seeing the frame and edges of the holograph while allowing the illuminated holographic image to appear as a three dimensional form. In this arrangement the holographic image may

appear to be in front of the two way mirror. With the usage of a motorised disk or cylinder a number of holographic images could be placed for a sequence of separate images or the holographic film could be a continuous strip for showing a moving three dimensional image. For an application as an interactive display it is possible to have a tray with a number of holographic plates which could be selected for display by the user.

In one embodiment of the invention the reflected three dimensional setting is a screen with a moving image from a motion picture projector or video/data projector which is front or rear projected. The screen can be a three dimensional surface which can accept the moving images over its varied surface. This can be combined with a real image that is a different moving image on a monitor or a projection screen having a flat or contoured surface with front or rear projection. The object can be displayed with mechanically driven movement, as by a turntable or a moving support to have the real image move in the area in front of the reflected background. The object itself can have its own movement, such as a motorised mechanical device or an animated figure or head.

In another aspect of the invention the two-way mirror can reflect directional sound from a speaker in the reflected three dimensional setting. This can be particularly useful for an image of an audioanimatronic figure or talking head. In large displays a separate speaker can be used for each real image.

This invention can incorporate a single mirror which is curved in the horizontal plane to cause the reflection of the object to focus as a real image which appears to be in front of the two way mirror. This can also be achieved with a single concave mirror.

This invention includes a preferred embodiment which places two curved, spherical or off-axis paraboloidal reflectors in a configuration that can form a real image in conjunction with a two-way mirror. It has long been known that by placing two spherical or paraboloidal reflectors in a configuration facing each other a real image can be formed. For many decades the principle has been used in amusement attractions for displaying objects, such as a 'magic penny'. This configuration is not the ideal since it requires that the two way mirror is placed in front of the optical path of the object and the optical reflectors causing the real image to be close to the two way mirror.

In an improved configuration the position of the real image is further in front of the two way mirror when the two reflectors are aligned so that the light from the first reflector is focused in the opposing direction as the light focused by the second reflector.

In another aspect of the configuration of the two reflectors in this invention it is possible to have the illusion of one real image changing to a second real image. This configuration allows for the insertion of a two-way mirror between the object and the first reflector. This two-way mirror is positioned so that the light on the first object passes through the two-way mirror to the first reflector. The second object is positioned so that the reflected image off of the two way mirror is in the focal region of the first reflector. When the second object is illuminated the light is reflected toward the first reflector. The illusion of changing the appearance of the image of the first object to the image of the second object is achieved simply by taking the light off the first object and adding light to the second object. This can be especially useful for entertaining displays where it would be possible to have the illusion of a real image transform into a totally different image, such as a three dimensional lifelike head magically turning into a humorous or

scary head. For educational displays in museums an image of an artifact could change into an image of a three dimensional outline model of the artifact with titles and graphics illustrating important features.

Another advantage of incorporating an additional mirror for viewing a second object is that it reverses the image to put it into the correct orientation for reading graphics. Previous optical systems using two reflectors could not solve this problem, whereas the present invention could be used for creating real images of existing products, such as displaying products for sale within store fronts or in store displays.

By placing products or other objects on a mechanical movement system, such as a turntable or conveyor belt, it is possible to have a number of different objects displayed individually within the optical system. This can be controlled either by an automated system or by a system that allows the viewer to select the object to be displayed.

The real image can appear to move closer to the viewer by having the object moved closer to the optical system. With the use of a computer to control the mechanised movement of the object the visual effect of the movement of the real image can be synchronised to match a projected computer based multimedia presentation, video or film image reflected off of the two way mirror to create a motion picture with a three dimensional real image superimposed in front.

In an advanced configuration of this invention the concave reflector is formed by creating a vacuum within a container covered with a thin reflective film on the face. The vacuum causes the reflective film to be drawn into the container in the form of a concave

surface.

By having a sensor built into the vacuum chamber it is possible to measure the exact distance that the film has been drawn into the chamber. An automatic control can have the vacuum pump pull the film to an exact position to achieve a desired focal point of the concave reflector.

By increasing the intensity of the vacuum the reflective surface is drawn in further to create a concave reflector with a shorter focal distance. This will cause the real image to appear to be further away from the viewer. With a decreased vacuum the reflective film will become a more shallow concave reflector which results in a longer focal distance to place the real image closer to the viewer.

For a rapid change to the curvature of the reflector it is possible to have a large ram on the vacuum chamber. The ram would be pulled out to increase the vacuum to cause the reflective film to be pulled back into a more concave shape to create a shorter focal distance. By driving the ram in and out the focal length of the concave reflector can be adjusted to accurately move the real image closer and further from the viewer. With a configuration where a large moving picture is reflected off the beamsplitter the real image would appear to move from the plane of the film to a position close to the audience. By having a computer controlling the movement of the rams the position of the real image could be exactly synchronised to have moving images of an object appear to jump out toward the audience at exact points within a moving picture presentation.

This invention solves the problem of displaying objects in close proximity of

visitors on a ride in an attraction or visitor centre. Due to considerations of public safety and vandalism it is not advisable to have objects within reach of visitors on rides. However, for the best appreciation and visual impact it is desirable for the images to appear to be within reach. This invention is ideal for this application in that the real images can appear within reach. This invention is preferable to an image appearing in front of a scrim which limits the object to placement in front of a flat surface. This invention allows for real images of objects to appear within three dimensional settings that are part of the overall themed interior of the ride.

The invention can be used to present moving pictures which have action on both a background and a foreground. The background can be a typical large projection screen which is reflected on a massive two way mirror. The foreground can be a moving picture that is rear projected on a screen that will appear as a real image between the background screen and the audience. This makes it possible to present a three dimensional moving picture for viewing without the usage of 3D glasses. Using large reflectors made of thin reflective film held in position by a vacuum the real image can be controlled to appear at different depths within the theatre. The real image could be a talking head created by having the video projected into a rear projection screen in the shape of a three dimensional head.

The experience of viewing the three dimensional moving picture can be even more exciting by having the seating area or the whole theatre moved to match the action on the screen. The combination of a ride simulator with the three dimensional imagery could create a more powerful sensory experience than with two dimensional film. It is also more effective than requiring the visitors to wear 3D glasses while viewing the motion

simulation ride.

The invention provides an opportunity for a new approach for a control interface. Prior to this invention it has been necessary to have a control interface which can be touched by the user. Most systems have been buttons, knobs, levers, or other control mechanisms which are operated by physical contact by the user. More recent developments have been 'touch screens' which display a number of choices on a computer monitor and are activated by sensors which register the touch of users. In all of these systems there is the inherent disadvantage of wear caused by physical contact by the user.

With the present invention it is possible to display a real image of a selection of buttons, knobs, levers or other control mechanisms which can give the illusion of being 'touched' by the user. Since the real images are in a definable space in front of the optical system and a sheet of glass it is possible to have sensors which can be triggered when the finger or hand of the user is in the exact position of a real image of a control mechanism.

Systems are currently available which sense a presence of the user's hand, such as a wash basin with a sensor to trigger water to run when a hand is placed under the faucet. The real images make it possible to achieve more complex operations than would be possible with a wide area position sensor. With the present invention it is possible to display a selection of real images of control mechanisms that float in a defined volume of three dimensional space. This provides a number of choices for the user.

Using the arrangements comprised in this invention it is possible to have a number of control panels that can be individually illuminated within the real image optical system.

The real image of a first control panel can be changed to the real image of a second control panel simply by changing the light from one side of a two way mirror placed within the path of the optical system. For further choices mechanical systems can sequence through a large number of control panels. This aspect of the invention is especially important in providing the user with multiple levels of choices. Once a choice is made on one level of the control panel a different selection of real images of control mechanisms can appear to allow further choices.

The control mechanisms can be more advanced than simple buttons in fixed positions since it is possible to have the position sensors register any position of a hand within the three dimensional space of the real images. The real image can be a lever which is operated by a motorised mechanism and controlled by the sensors to follow the hand of the user. In this way the user can control variables provided by the control system, such as controlling temperature, lighting levels, audio levels, speed of motors, flow rates, etc.

In applications, such as manufacturing or equipment operation, the display of real images of control mechanisms could make it possible to perform complex operations without having to physically touch the controls. This can be especially useful in facilities where there is extreme heat, such as a bakery or kiln.

Since the real images are not restricted to a single two dimensional plane, control mechanisms can be positioned within the depth of the real image. Previous systems of touch screens have been limited to a two dimensional plane. With the present invention it is possible to have control positions surrounding and within three dimensional real

images. This is especially useful when the objective is to provide information about a subject which is three dimensional. As an example, the user could touch different parts of a real image of the anatomy of human body which would trigger displays showing cutaways and information. For commercial exhibitions a complex three dimensional object, such as an engine, could be displayed as a real image with different parts that could be touched to trigger information about features of the engine.

The invention can be useful for interactive displays positioned in public places. The real images of the control mechanisms will not become dirty or contaminated. The cost of the control mechanisms will be minimised since they do not have to be constructed to withstand prolonged battering by thousands of users and the destructive acts of vandals. There will be virtually no cost to upkeep and replacement. Since the control mechanisms are never touched they can be delicate which provides an opportunity for attractive and visually interesting designs for the control mechanisms.

Since the invention provides a novel and unique means of interacting with control mechanisms it is ideal for a new format for games. The controls can be a combination of video/computer images and real three dimensional objects. The player can move to higher levels of play by achieving the objectives of the game. As a three dimensional game the player can undertake new challenges that are not possible with a two dimensional format.

The real image control system can be used to trigger actions that take place in the position of the real image. As an example, the display could show one or more real images of perfume bottles. When the user places his/her hand in the position of one of the perfume bottles the sensor would trigger a dispenser to spray that perfume onto the hand.

Since the real image can be an attractive display of the actual bottle of perfume it is not necessary to produce a mock-up of the bottle to withstand the liabilities of damage from public display.

With the use of curved reflectors the invention creates a real image by focussing the light into a focal region. The same system can focus infrared light as effectively as light in the visible spectrum. In this way it is possible to have an interactive display with a visual presentation of information where one of the choices is to activate a heating element as one of the real images. By placing his/her hands on the real image of the heating element his/her hands could be warmed. Since the actual heating element is behind the protective glass of the two way mirror the user is protected from the dangers of touching the actual heating element. The display could be positioned on an exterior wall of a building so that the real image of the heating element was available for users outside.

The invention can be used in a vending machine where the user would be able to interact with a real image of a control mechanism to select real images of products available within the vending machine. The selected products would be moved by a mechanism to the display position of the optical system. Upon paying for the product an actual product would drop from the dispenser to appear in the same position as the real image.

Specific embodiments of the invention will be described by way of example with reference to the accompanying drawings in which:

Fig. I show the invention as a single user display with a reflected monitor with image of superimposed object

Fig. 2 shows the invention as an exhibition display with projected video/data image background with image of superimposed object

Fig. 3 shows the invention as a theatre with a projected video/data image background with image of superimposed object

Fig. 4 shows the invention using a sheet of holographic film

Fig. 5 shows the invention using a disk of holographic film

Fig. 6 shows the invention using a cylinder of holographic film

Fig. 7 shows the invention with a tray of holographic plates

Fig. 8 shows the invention using a single reflector configuration.

Fig. 9 shows the invention using two inward facing concave mirrors

Fig. 10 shows a cross section of the invention with an object reflected in two concave reflectors to achieve a first real image with the addition of a means for showing a second real image.

Fig. 11 shows an embodiment of the invention with a monitor reflected in the two way mirror for displaying a a background of a moving image behind the real image.

Fig. 12 shows an embodiment of the invention with a rear projection screen reflected in the two-way mirror for displaying a background of moving images behind the real image and two mechanisms for moving the display objects.

Fig. 13 shows an embodiment of the invention with a front projection surface reflected in the two-way mirror for displaying a background of moving images behind the real image.

Fig. 14 shows a turntable and a conveyor system that can change objects within the focal region of the optical system

Fig. 15 shows a translation stage for changing objects in the focal region and a mechanism for sliding a mirror in and out of the optical path

Fig. 16 shows a means of changing the position of the real image by moving the object or by changing the curvature of the reflectors

Fig. 17 shows an application of the invention within a visitor attraction

Fig. 18 shows an application of the invention within a presentation theatre

Fig. 19 shows an application of the invention with an audience movement system

Fig. 20 shows a cross section of a system to sense the placement of a hand on an illusion of a real image of a control mechanism

Fig. 21 shows a front view of a system to sense the placement of a hand on an illusion of a real image of a control mechanism

Fig. 22 shows in cross section a control system with real image reflectors and monitor

Fig. 23 shows a front view of real image controls with monitor

Referring to the drawing Fig. I a person 4 views a reflection of a monitor 13 which is reflected in a two way mirror 5 and sees an object 1, against a perceived position 30 of the monitor 13.

In Fig. 2 is seen a larger arrangement of the invention where a person 4 views a reflection of an image on a rear projection screen 14 which has been projected by a video/data projector 15. A front surface mirror 23 has been positioned in the projection path to make it possible to make an enclosure for the invention that is more compact. The viewer 4 sees an image of the object 1 through the two way mirror 5 which appears to be superimposed over the apparent position of the reflected image 30.

Fig. 3 is a similar arrangement adapted for viewing by an audience 4. A large video/data projector 15 projects an image onto a rear projection screen 14 by reflecting off a front surface mirror 23. The audience 4 sees the object 1 superimposed over an

apparent background 30 which has been reflected off a two way mirror 5.

In Fig. 4 a sheet of holographic film 9 is placed behind the two-way mirror 5. A bright light source 8 shines light onto the holographic film. The reflected image of the background 6 will appear behind the holographic image 3 and will obscure the sheet of the holographic film 9 other than the bright three dimensional image of the holographic film illuminated by a light 8.

Fig. 5 shows the holographic film in the shape of a disc 9 which can be comprised of a series of separate holographic images. As the disc is rotated each individual holographic frame will be illuminated by the light 8 so that the holographic image appears in position 3. The holographic film 9 can be created as an animation of three dimensional imagery which will appear in position 3 as a moving image as the disk is rotated.

Fig. 6 shows the holographic film in the shape of a cylinder 9 which can be comprised of a series of separate holographic images. As the cylinder is rotated each individual holographic frame will be illuminated by the light 8 so that the holographic image appears in position 9. The holographic film 9 can be created as an animation of three dimensional imagery which will appear in position 3 as a moving image as the cylinder is rotated.

Fig. 7 shows a tray 31 which holds a number of holographic plates 9. The holographic plates are individually moved into position for the light 8 to illuminate a holographic image in position 3.

In Fig. 8 an object 1 is reflected in a curved mirror 2 to form a real image 3 which is viewed by a person 4. The light reflected from the curved mirror 2 passes through a two way mirror 5 without causing any distortion or alteration to the image. By doubling the light cast on the object 1 it is possible to compensate for the light loss of the two-way mirror 5 which may typically transmit only 30% to 50% of the light on the object 1. The real image 3 appears in front of the two-way mirror 5. By laminating the two way mirror 5 to a thick sheet of glass it is possible to protect the object 1 from theft or damage. Any other substance such as tough plastic which has been partially mirrored could be used as the two-way mirror 5. In other applications the protective glass laminated to the two-way mirror 5 can protect the observer 4 from any dangerous substances in the area of the object 1, such as radioactive materials or poisonous vapours. The setting for the image 3 will include a structure 7 that keeps the viewers from moving so close to the apparatus that they could not view the image properly.

In addition to allowing the passage of light for forming a clear view of the image the two way mirror reflects an image of a background 6. This background 6 will appear to be behind the image 3. The light on the background 6 can be controlled to be dim enough not to wash out the image 3, yet light enough to obscure the apparatus behind the two way mirror. The background 6 can be a three dimensional shape that provides a more suitable setting for the image 3 than a flat background.

In a more advanced embodiment illustrated in Fig. 9 the object 1 is reflected in a portion of a sphere or an off axis section of a paraboloid 10 to cause parallel light to pass to a second spherical or paraboloidal reflector which converges the light to form a real image 3. This pair of reflectors can produce a real image with less distortions than a

single concave reflector. There is a disadvantage to this system in that the real image may not appear to be fully in front of the two way mirror 5.

In a preferred embodiment in Fig. 10, two spherical or off axis paraboloidal reflectors are arranged so that the path of light from the reflector 10 does not pass between the reflector 2 and the two-way mirror 5. This arrangement makes it possible for the real image 3 to appear fully in front of the two way mirror 5 and closer to the viewer 4.

For display and entertainment applications the addition of a second two-way mirror 11 allows a second object 12 to be viewed in the one apparatus. When the first object 1 is illuminated the light passes through the two-way mirror and then through the apparatus to converge in the position of the real image 3. When the first object 1 is in the dark and the second object 12 is illuminated the light is reflected off the two-way mirror and the light passes through the apparatus to converge in the position of the real image 3. It should be noted that an image of the object I passing through the two paraboloidal reflectors will converge to display a real image 3 that is reversed in the same manner that a normal mirror reverses an image. As a consequence, any graphics on the object will be reversed and will be difficult to read. However, the reflected image of the second object 12 will be reversed again to achieve a normal view of the object as a real image 3. This is also important for correcting the orientation of objects which would appear upside down if placed in the position of the object 1.

Fig 11 shows how a computer or video monitor 13 can be reflected on the two-way mirror 5 to achieve a moving image behind the real image 3. The object 1 and/or object

12 can be a computer or video monitor to place a moving image in the position of the real image 3. In this way it is possible to create a moving real image 3 in front of a moving background 13. A controller is used to synchronise the video or data sources for the moving imagery on the two monitors.

In Fig. 12 the background 14 is a rear projection screen which can have a moving image projected on it from a film, video or data projector 15. This makes it possible to have a large surface covered by a moving image which can provide a background for a real image 3. The object 1 is on a turntable 28 which can be rotated to cause the real image 3 to be rotated. The object 12 is on a translation stage 29 which can used to move the position of the object 12 so that the position of the real image 3 appears to move. Since it is possible to control the lighting on the object 1 and/or 12 so that the mechanical movement system is not illuminated, the real image could appear to move freely. This would cause the real image 3 to appear to be moving within the setting of the reflected background 14.

In Fig. 13 the background 16 is a surface that will accept a projected image from a film, video or data projector 15. The surface can be a flat screen or a three dimensional surface that is designed to work with the projected image. With this method the image can appear to be in front of a three dimensional surface that is changing in colour, lighting levels and apparent motion. The background 16 can incorporate mechanical movement to display actual motion behind the real image 3.

In Fig. 14 the object 1 is on a conveyor belt 41 which can be controlled by an automated programme or by an interactive display operated by the user so that a selection

of objects I are moved to the focal region of the optical system to display real images in the position 3. As an example of another multiple display system, the object 12 is one of a number of objects on a turntable 40 which can be rotated to selectively display real images objects in position 3.

In Fig. 15 another movement system, a translation stage 42, can move laterally to place a number of objects 1 in the focal region for display of a real image in position 3. In this illustration a two way mirror is not used in the optical path between objects 12 and 1. A front surface mirror 44 is placed on a translation stage 43 so that the mirror can be moved in and out of the optical path. When the mirror is out of the optical path a real image of the object I is displayed in position 3 and when the mirror is in position in the optical path the object 12 is reflected so that the real image is displayed in position 3. The advantage of this system is that there is not the 50% light loss of the transmitted or reflected image resulting from using a two way mirror. Another important feature of the mirror 44 on the translation stage 43 is that the lights used to illuminate objects 1 and 12 can remain on constantly eliminating the need for using dimmable lighting and the costs of dimmers.

In Fig. 16 the curvature of the mirrors 19 can be adjusted to change the focal distance for the object 1 and/or 12 and the real image 3 so that the real image appears to move to position 20 even though the object itself has not been moved. As a separate form of movement or in combination with the change of the curvature of the mirrors the object 1 and/or 12 can be moved on a translation stage 45 to position 21 closer to and further from the optical system in order to move the real image 20 closer to and further from the viewer.

In Fig. 17 an amusement ride is illustrated where the arrangement is set within a visitor attraction where the observer 4 would be on a vehicle 17 which would bring the observer 4 to the optimal position for viewing the real image 3.

In Fig. 18 the invention is shown within a presentation theatre. The background 14 is a large rear projection screen with the projected image from a slide, film, video or data projector 15 which is reflected off of a mirror 23. The screen 14 appears to be in a vertical position 24 as it is viewed as a reflection off of the two way mirror 5. The object 12 is a rear projection screen which is projected from a projector 22 and reflected off of a mirror 25. Other rear projection screens 26 are placed on a turntable or other mechanical movement system 18. The screens 26 can be curved in the form of a hemisphere, irregular shape or the form of a person's head so that the real image 3 appears as a three dimensional object with a moving image on the face of it. The real image 3 is a moving image seen against the reflected screen 24 so that the synchronised projected images appear on multiple planes to create the illusion of a three dimensional motion picture.

In Fig. 19 the invention is shown within a theatre where the audience is on a movement system 27.

In Fig. 20 a person 4 views real objects 3 and 50 which appear to be in front of a two way mirror 5. The background 13 is reflected in the two way mirror 5 so that it appears to be behind the real images. If the person were to put his/her hand in the position of the real image 3 the hand would break a beam 60 emitted from a source 54 and reflected on a retroreflective mirror 52. If the person put a hand in the position of the real image 50 the hand would break the beam 61 being emitted from the source 53 and

reflected on the retroreflective mirror 51. It should be noted that the hand could also break the beam 60 between 54 and 52 when reaching for the real image 50.

A computer controller or dedicated programmer could be set to delay the response to a break of the beam 60 closer to the user so that if the beam behind 61 were to be broken the computer would ignore the closer beam 60 and trigger the function dedicated to beam 61.

In a different approach the invention uses ultrasonic proximity sensors in the positions of 53 and 54. Since these sensors are capable of recognising the distance of the hand from the sensor it is possible to trigger the function only when the beam is broken at the position of the real image of the button 3 or 50. With this system it is possible to reach for the real image 50 causing the beam 60 to be broken, but only triggering the function dedicated to the real image 50.

With the usage of ultrasonic proximity sensors it is also possible to operate a slider control where the real images 50 and 3 are of control mechanisms that can be mechanically moved to match the distance that the hand is from the sensors 53 and 54 along the corresponding lines of ultrasonic sound 61 and 60.

In Fig. 21 we see a front view of the two way mirror 5 with real images 3 and 50, 70 and 71. The control system can have a logic that requires both the horizontal and vertical beams to be broken in order to register a selection. If for example, beam 60 was broken by itself the control system would not register a selection. It would be necessary for both beams 60 and 63 to be broken to register the selection for the position of the real

image 3. In the same manner both beams 62 and 61 must be broken to register the selection in the position of real image 50.

In Fig. 22 we see a cross section of a control system where the display object 1 is one of a number of objects on a turntable 40 which can be rotated to the focal region of the reflector 10. A monitor 73 is positioned above the optical system so that it can be viewed directly through the protective transparent sheet 5. A dispensor 73 is positioned below the real image 3 so that it will spray mist onto the hand of the user when the user puts his/her hand in the position of the real image.

In Fig. 23 we see a front view of a control system where the monitor 72 is positioned above the real images 3, 71 and 73. Each of the real images have their own reflectors to focus light from the individual control devices.

Further variations and modifications can be made to the invention within the scope of the following claims.

CLAIMS

1. An arrangement for displaying an aerial image of an object comprising an optical system for forming the aerial image, a two way mirror through which the image is projected to a viewing position by the optical system and a background panel arrangement which is reflected to the viewing position by the two way mirror so that an aerial image focused by the opitcal system is seen from the viewing position against a reflection of the background.

2. An arrangement which superimposes images of objects or real images onto a background without requiring lenses by using a two-way mirror through which the images are viewed and a background panel arrangement which is reflected to the viewing position by the two-way mirror so that the objects or real images focussed by the reflectors are seen from the viewing position against a reflection of the background.

3. The arrangement as claimed in claim 1 or claim 2, wherein an object is positioned directly behind a two way mirror which reflects a background which appears to be behind the direct view of the object.

4. The arrangement as claimed in claim 1 or claim 2, wherein the optical system comprises a sheet of holographic film illuminated from behind so that the holographic image appears in front of the two-way mirror.

5. The arrangement as claimed in claim 1 and 4, wherein a set of holographic plates is placed on a disk which can be rotated in order to illuminate each of the individual

holographic images.

6. The arrangement as claimed in claim 1 and 4, wherein a sheet of holographic film, which has been produced with an animated sequence of motion around the circumference of a disk, is placed on a rotary device which will display the animated motion when the disk is rotated.

7. The arrangement as claimed in claim 1 and 4, wherein a set of holographic plates is placed on a cylinder which can be rotated in order to illuminate each of the individual holographic images.

8. The arrangement as claimed in claim 1 and 4, wherein a sheet of holographic film, which has been produced with an animated sequence of motion in a linear strip, is placed on a cylinder with a rotary device which will display the animated motion when the cylinder is rotated.

9. The arrangement as claimed in claim 1 and 4, wherein holographic plates are stored in a tray and are moved into position individually for illumination to display the holographic images.

10. The arrangement as claimed in claim 1 or claim 2, wherein the optical system comprises a single mirror curved in the horizontal plane to invert the image laterally and positioned so the light from the object converges as a real image in front of the two-way mirror.

11. The arrangement as claimed in claim 1 or claim 2, wherein the optical system comprises a single mirror which is a portion of a concave, spherical or paraboloidal reflector positioned to converge the light from the object as a real image in front of the two-way mirror.

12. The arrangement as claimed in claim 1 or claim 2, wherein the optical system is based on two concave, spherical or off axis paraboloidal reflectors aligned to be facing each other so that the object and real image are offset, yet on the same side of the apparatus, whereby an object placed in the focal region of a first reflector causes parallel light to pass to a second reflector which refocuses the light rays to create a real image in the focal region of the second reflector so that a real image appears in front of the two-way mirror.

13. The arrangement as claimed in claim 1 or claim 2, wherein the optical system is based on two concave, spherical or off axis paraboloidal reflectors aligned to be facing each other so that the object is on the opposite side of the apparatus from the position of the real image, whereby an object placed in the focal region of a first reflector causes parallel light to pass to a second reflector which refocuses the light rays to create a real image in the focal region of the second reflector so that a real image appears in front of the two-way mirror.

14. The arrangement as claimed in claim 12 or claim 13, wherein a two-way mirror is placed in the optical path between a first object and a first reflector so that a second object could be illuminated alternatively to create a real image in place of that of the real image of the first object or that the real image of the first object and the real image of the

second object are superimposed.

15. The arrangement as claimed in claim 12 or claim 13, wherein a mirror is placed in the optical path between a first object and a first reflector so that a second object could be reflected to display a real image by way of the optical system and alternatively when the mirror is moved out of the optical path a real image of the first object is displayed.

16. The arrangement as claimed in any one of the preceding claims, wherein the object is a computer or video monitor which would display moving images to be focussed in the optical system to create a real image of moving imagery.

17. The arrangement as claimed in any one of the preceding claims, wherein the object is on a turntable or a mechanical movement system to cause the real image to have motion.

18. The arrangement as claimed in any one of the preceding claims, wherein the object in the optical path of the first reflector and/or the second object reflected in the mirror or two way mirror is one of the many objects on a translation stage, conveyor belt, indexed turntable or other mechanical device that can position the objects in series or by interactive selection to move to the focal region of the optical system for viewing.

19. The arrangement as claimed in any one of the preceding claims, wherein the object is on a translation stage or other mechanical movement system which moves the object within the focal region of the optical system to positions that are closer and further from the focal point of the optical system in order to achieve a real image that appears to

move closer and further from the viewer.

20. The arrangement as claimed in any one of the preceding claims, wherein the curvature of the reflector or reflectors of the optical system is adjusted to change the focal length so that the real object appears to be moved either closer or further away from the viewer.

21. The arrangement as claimed in any one of the preceding claims, wherein the background reflected off the two-way mirror is a computer or video monitor with moving images to achieve an illusion of movement behind the real image.

22. The arrangement as claimed in any one of the preceding claims, wherein the background reflected off the two-way mirror is a rear projection screen with moving images to achieve an illusion of movement behind the real image.

23. The arrangement as claimed in any one of the previous claims, wherein the background reflected off the two-way mirror is a flat or irregular surface with moving images projected on it to achieve an illusion of movement behind the real image.

24. The arrangement as claimed in any one of the preceding claims, wherein the background reflected off the two-way mirror is a surface or number of surfaces which incorporates mechanical movement to show actual movement behind the real image.

25. An amusement ride, comprising a ride vehicle which moves visitors to the position

for viewing the real image of the arrangement as claimed in any one of the preceding claims, wherein the arrangement is placed in a facility for public viewing.

26. A presentation theatre comprising a seating area for viewing of a projected film or video with real images within arrangements as claimed in any one of the preceding claims.

27. A motion simulation ride wherein there is a movement system for the seating area or the entire theatre so that the audience is moved in synchronisation with the viewing of a projected film or video with real images within arrangements as claimed in any one of the preceding claims.

28. Apparatus according to any one of the preceding claims, in combination with an audio system.

29. Apparatus according to claim 28, in which the audio system comprises a stereo sound system which is spatially coordinated with the imaging system.

30. Apparatus according to any one of the preceding claims, in combination with a position sensing system sensing the positions of objects (such as fingers) placed on images (such as images of push buttons) and a control arrangement effecting operations in response to the presence or absence of objects sensed by the sensing system.

31. Apparatus comprising an imaging arrangement producing a 3D aerial image including images of control members (such as push buttons) in combination with a

position sensing system sensing the positions of objects (such as fingers) placed on control member images within the 3D image and a control arrangement effecting operations in response to the presence or absence of objects sensed by the sensing system.

32. A control system where a sensing system is triggered when the user places his/her hand or finger in the position of the appearance of a real image or holographic image.

33. A control system according to any one claims 30 to 32, in which the sensing system comprises an infra red sensor.

34. A control system according to any one of claims 30 to 33 , in which the sensing system comprises a microwave detector.

35. A control system according to any one of claims 30 to 34, in which the sensing system comprises an ultrasonic proximity sensor.

36. A control system using a number of sensors that are individually triggered when the user places his/her hand or finger in the position of the appearance of a one of a corresponding number of real images or holographic images.

37. A control system according to any one of claims 30 to 36 using a number of sensors that are individually triggered when the user places his/her hand or finger in one of a number of a predetermined positions within the three dimensional space of the appearance of a real image or holographic image.

38. A control system as claimed in claim 37, where a number of sensor beams are aligned within the vertical and horizontal axis of a two dimensional plane in order to cross at a number of positions which match specific positions of the appearance of one or more real images or holographic images so that when the user puts his/her hand or finger in one of the said positions both of the crossing beams are broken and therefore a computer or programmer registers a selection has been made for the said position.

39. A control system as claimed in claim 38, where there is more than one two dimensional plane of sensor beams which are positioned behind each other to cover the depth of the three dimensional space of the real images or holographic images and are triggered after a short delay to allow the computer or programmer to ignore any triggering of the sensors in the planes closer to the user and to register the selection of a position in the farthest most two dimensional plane of sensors.

40. The arrangement as claimed in any one of claims 30 to 39, where a transparent sheet of protective glass, unbreakable plastic or laminated materials is positioned between the optical system for producing real images or the sheet of holographic film and the focal region of the real image or holographic image.

41. The arrangement as claimed in claim 40, where the transparent sheet is angled so that any reflected image as seen by the user is of a shield instead of any undesirable reflections.

42. The arrangement as claimed in claim 40 or claim 41, where the transparent sheet is partially mirrored and the shield reflected in the protective glass is illuminated so that

the reflection obscures the apparatus that is used to produce the real images or holographic images while not being so bright as to obscure the illuminated real images or holographic images.

43. The arrangement as claimed in any one of claims 40 to 42, where a monitor is positioned behind the transparent sheet for displaying information and visuals supporting the selection of the real images as they are all viewed through the transparent sheet.

44. The arrangement as claimed in any one of claims 40 to 43, where the reflected image is of a monitor or rear projection screen.

45. The arrangement as claimed in any one of claims 32 to 44, where a dispenser sprays a mist or dispenses a fluid onto the hand of the user when the user puts his/her hand in the position of the real image or holographic image.

46. The arrangement as claimed in any one of claims 32 to 44, where the real image is of a heating element which is triggered to emanate infrared heat waves when a user places his/her hands in the position of the real image.

47. The arrangement as claimed in any one of claims 32 to 46 where the real images are on rotary devices which can be rotated to move different buttons or control devices into the focal region of the optical system so that a selection of different real images will appear in each of the positions where sensors are aligned to trigger functions.

48. A game based on the interaction of the user with real images or holographic

images as claimed in any one of claims 32 to 47.

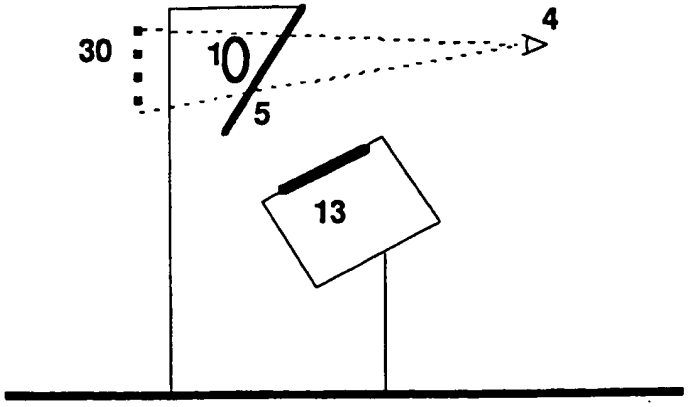

Fig. 1

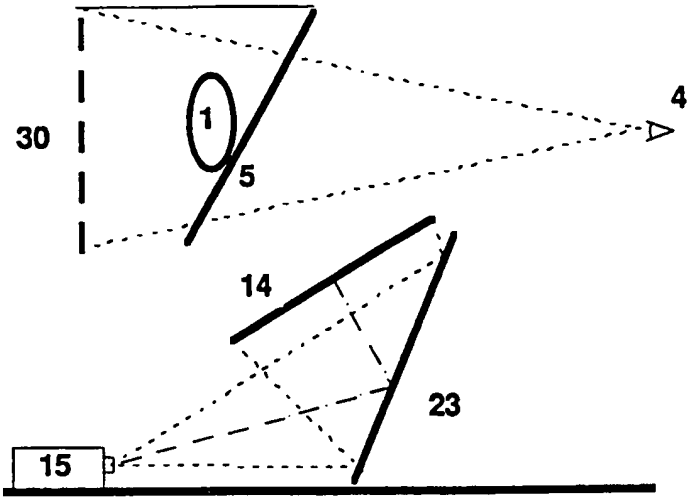

Fig. 2

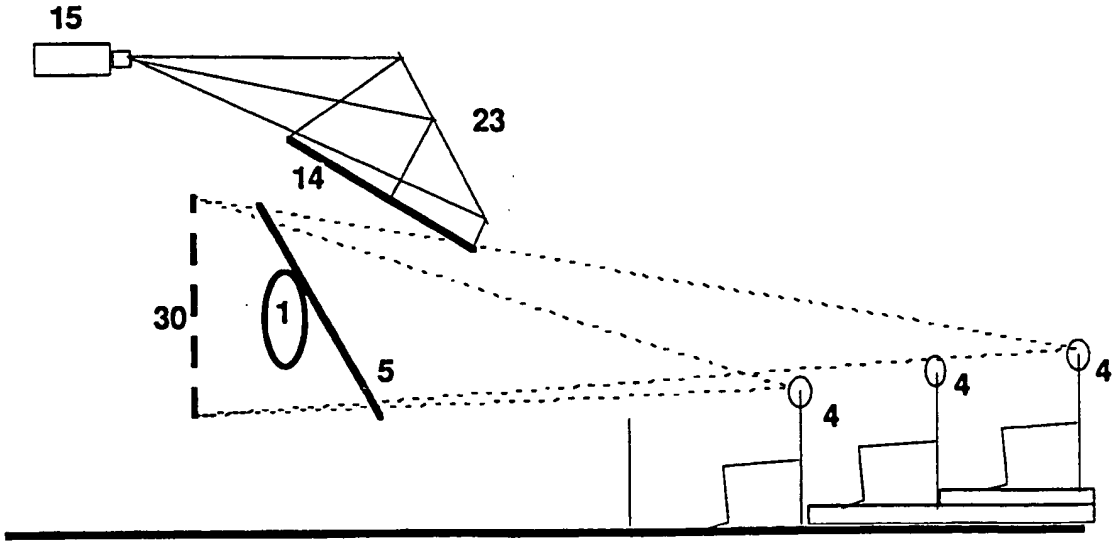

Fig. 3

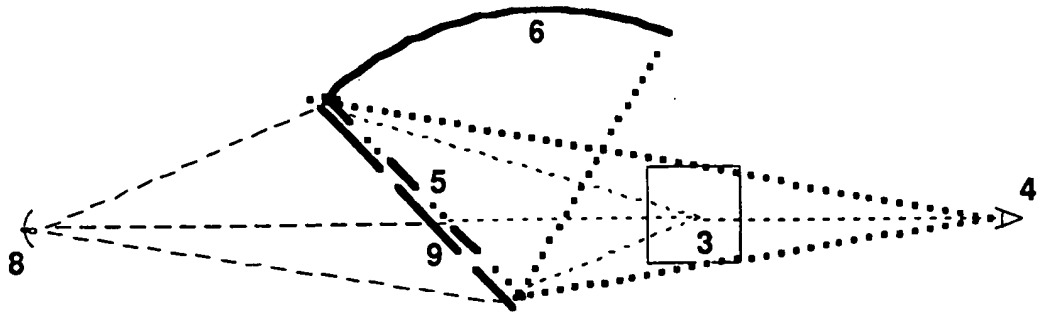

Fig. 4

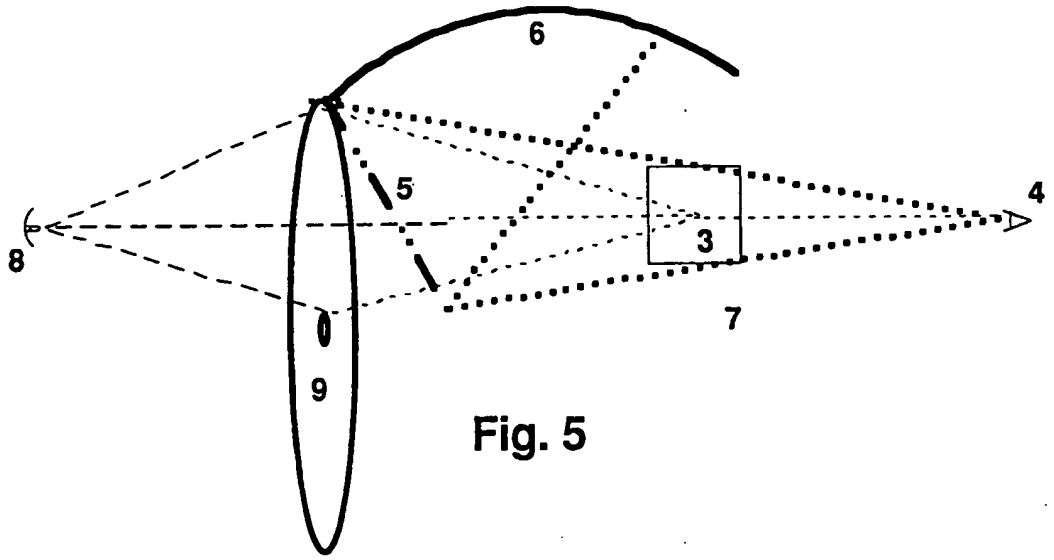

Fig. 5

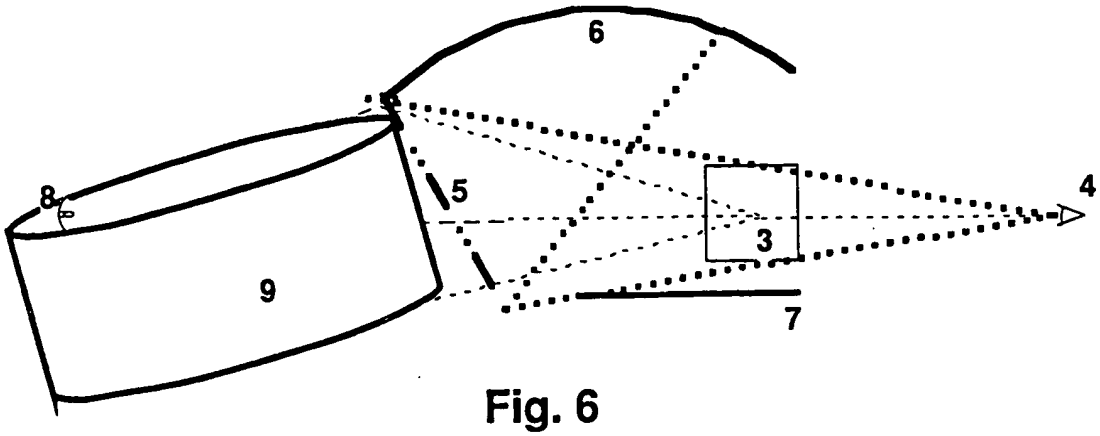

Fig. 6

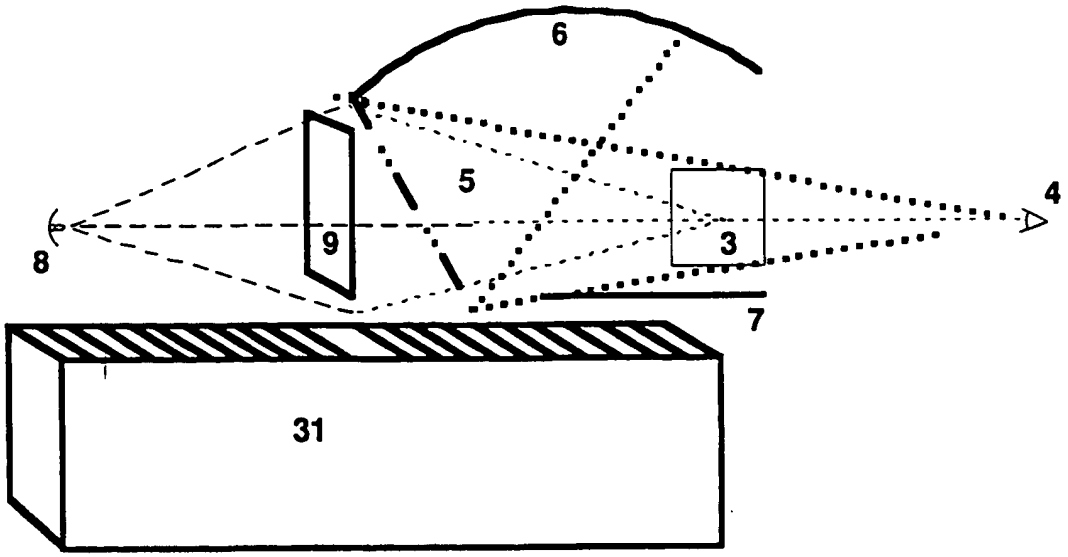

Fig. 7

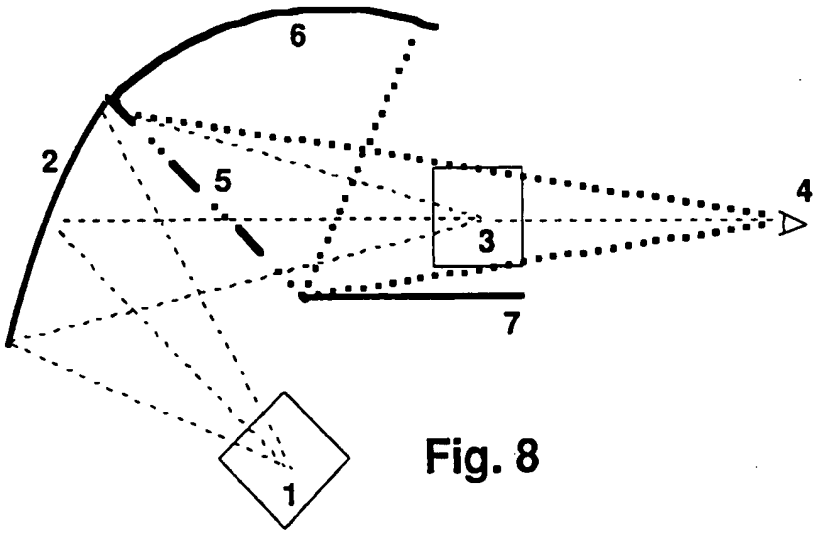

Fig. 8

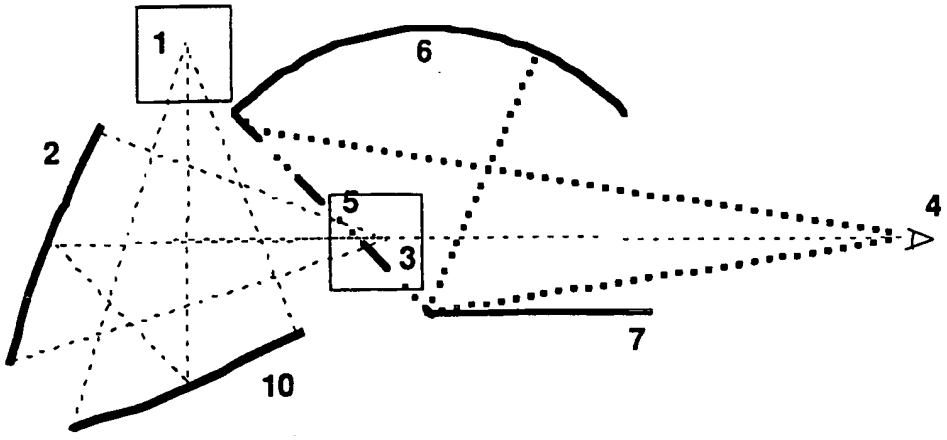

Fig. 9

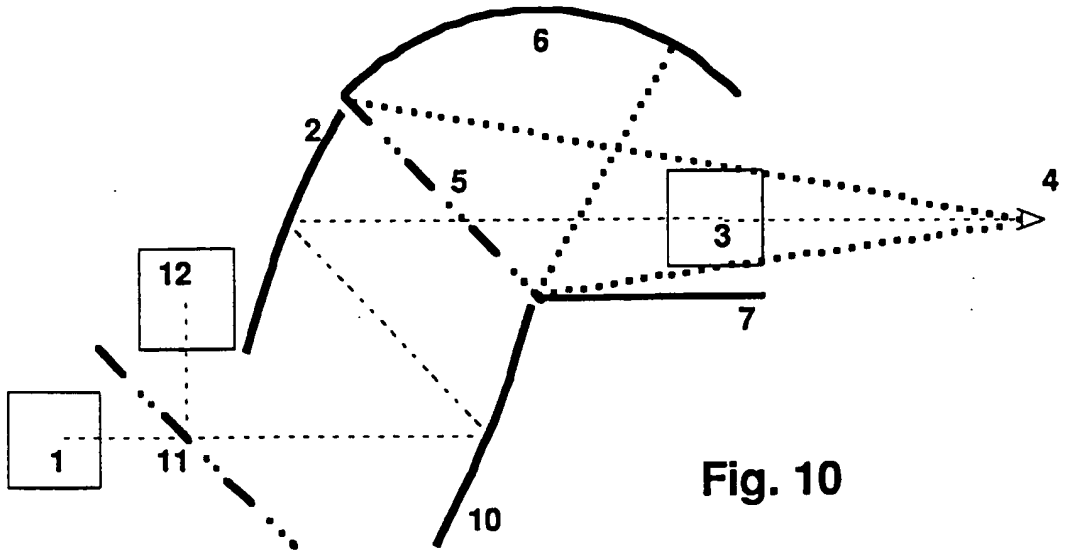

Fig. 10

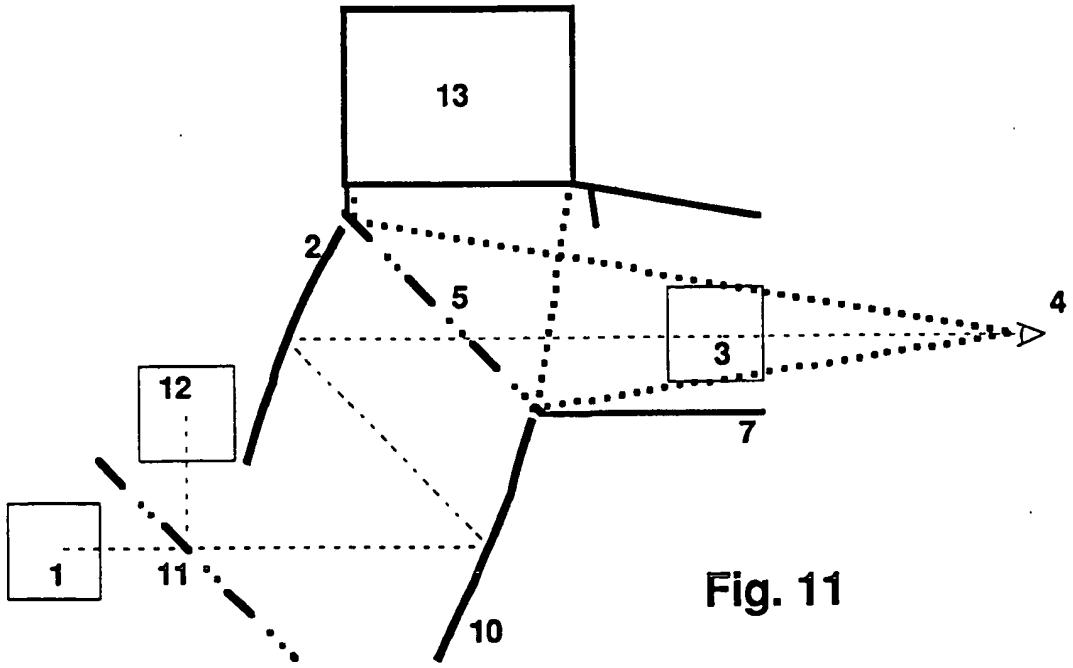

Fig. 11

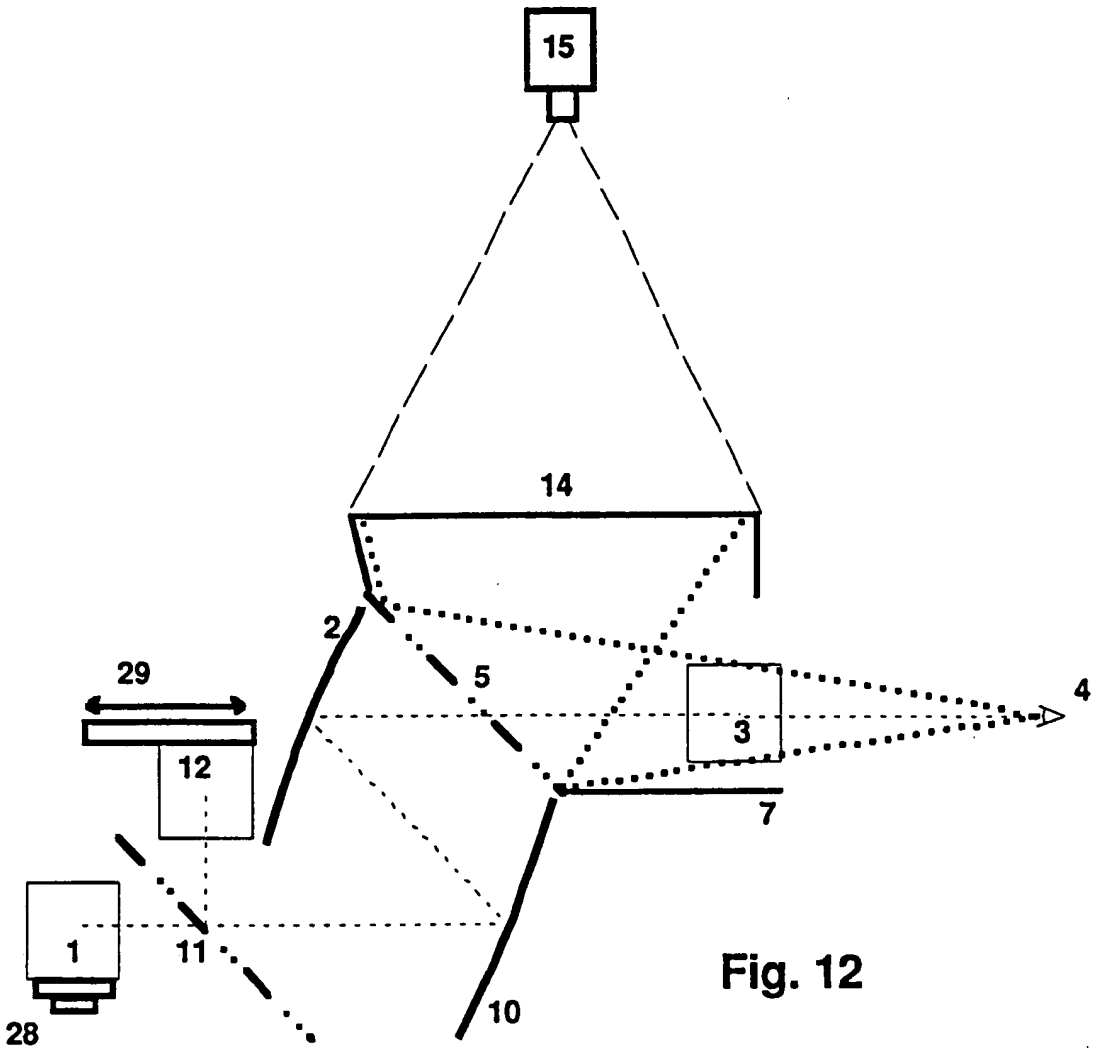

Fig. 12

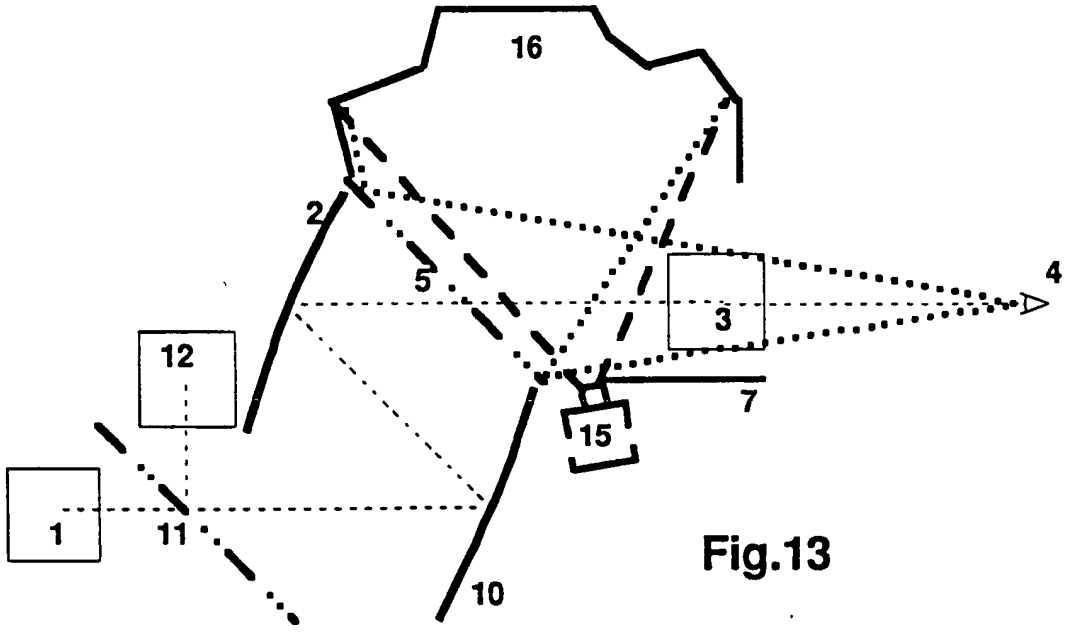

Fig.13

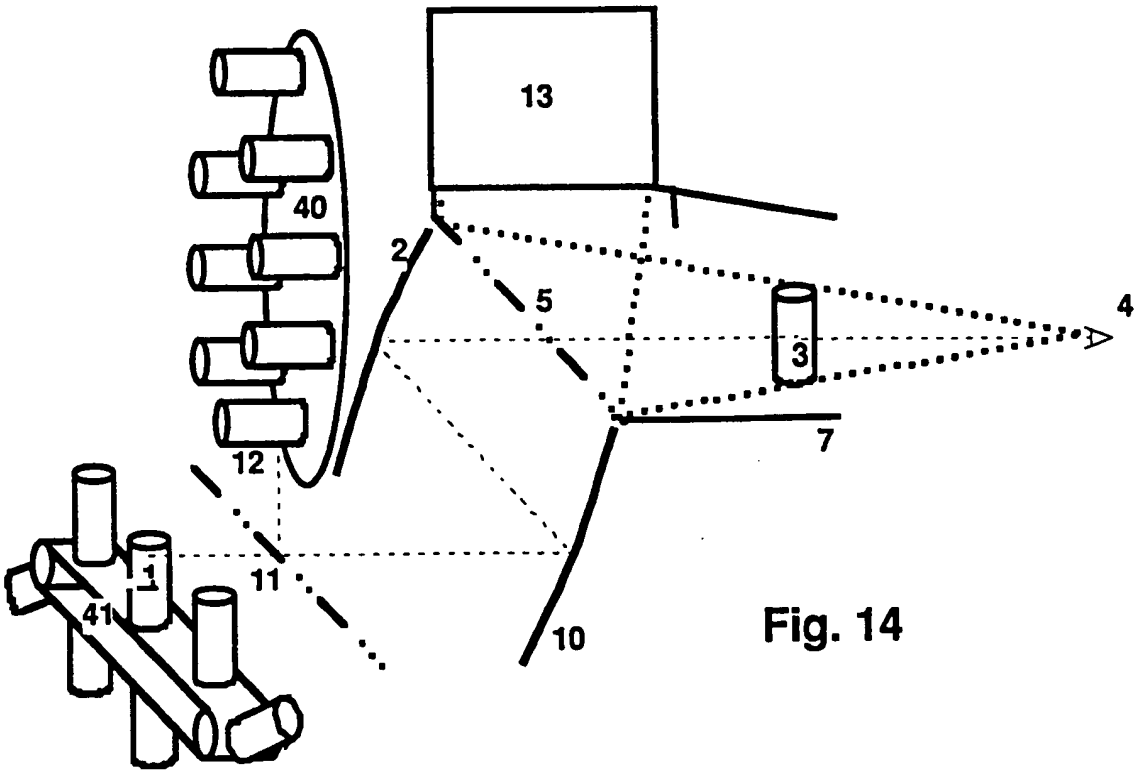

Fig. 14

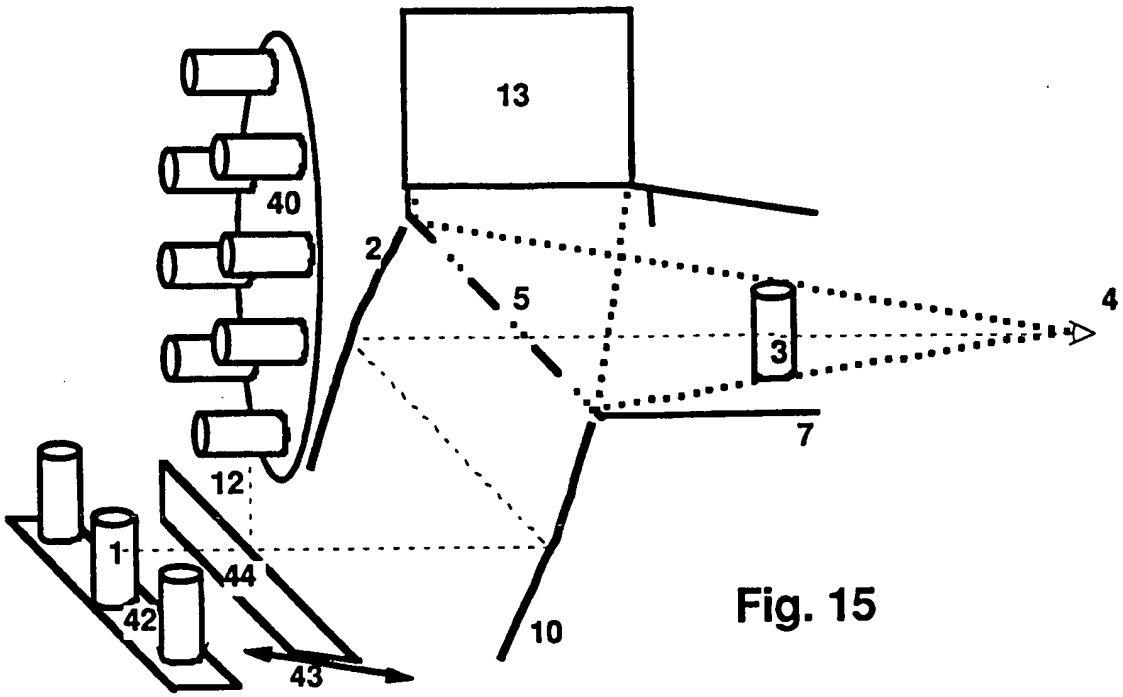

Fig. 15

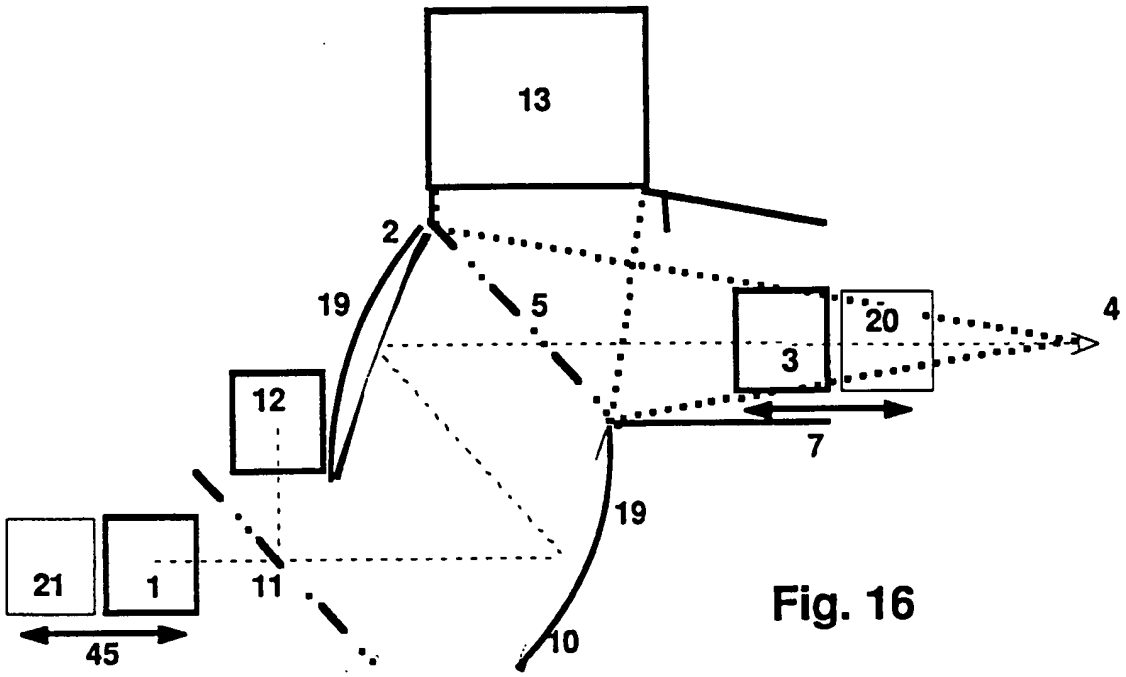

Fig. 16

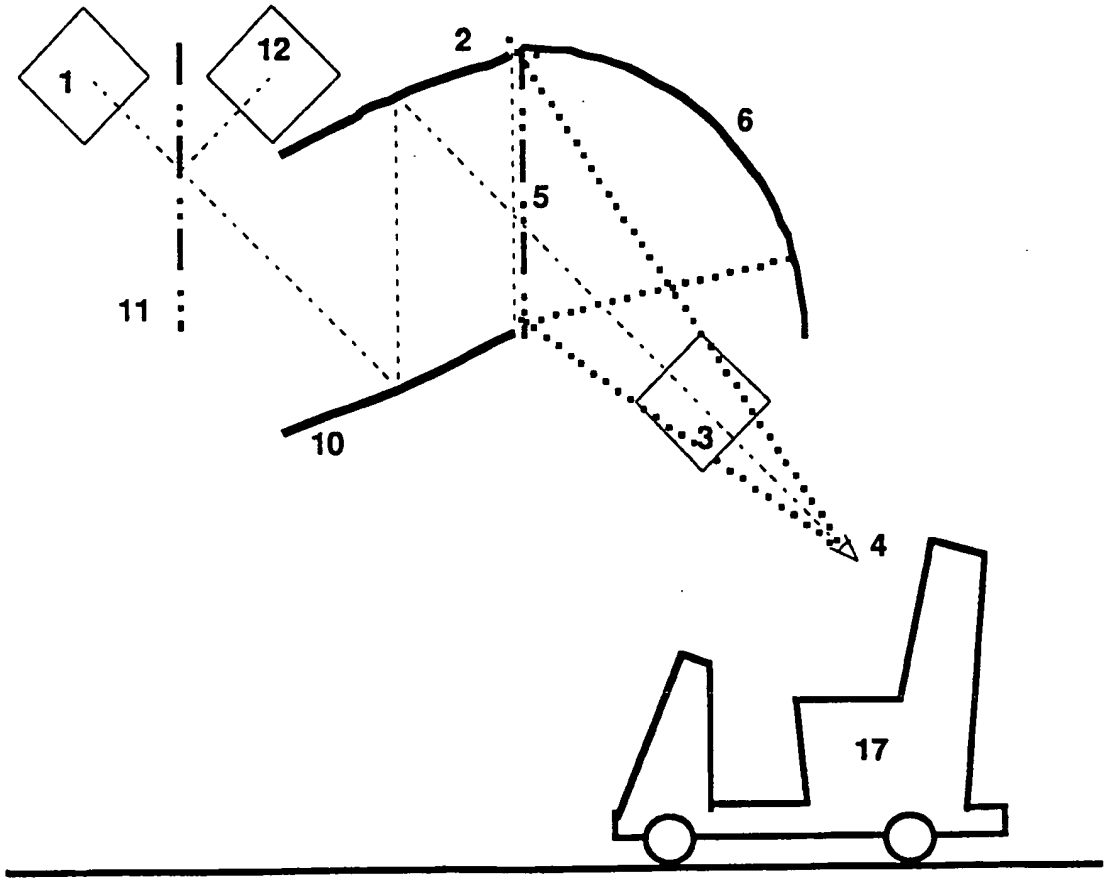

Fig. 17

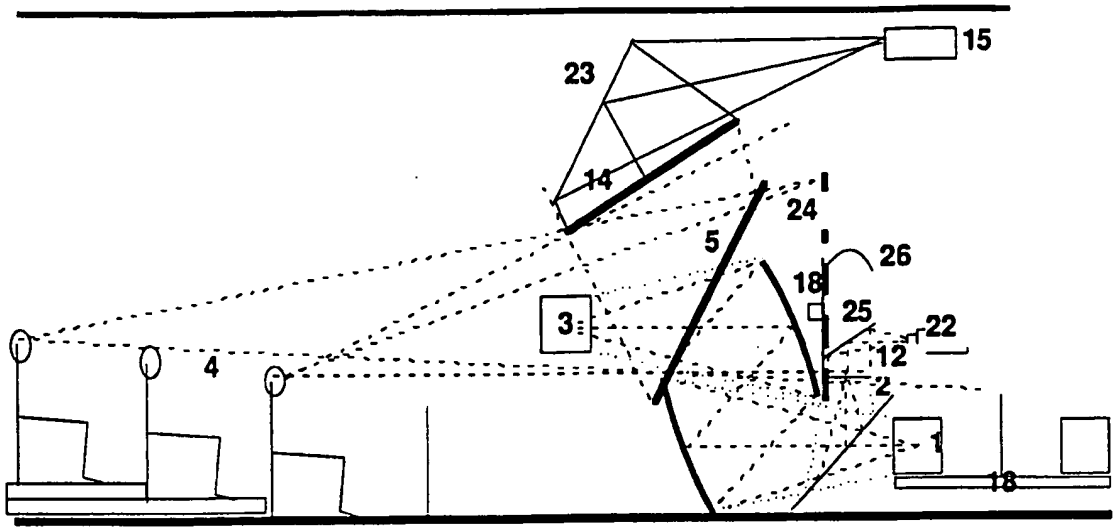
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Fig. 18

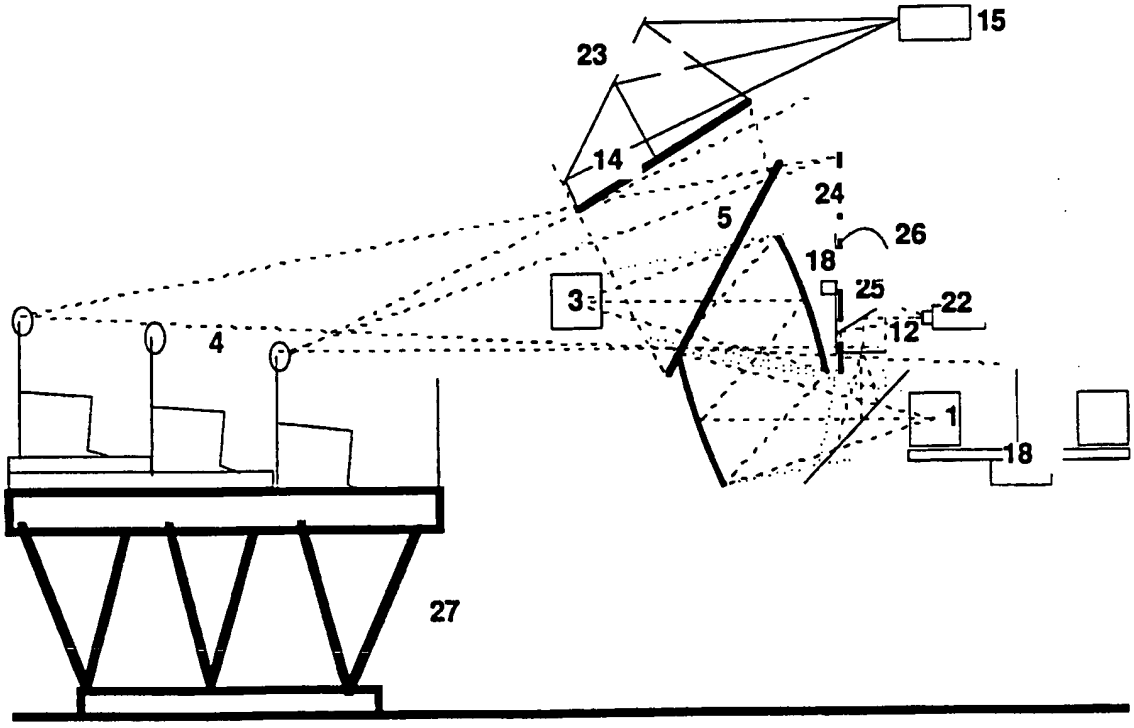
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Fig. 19

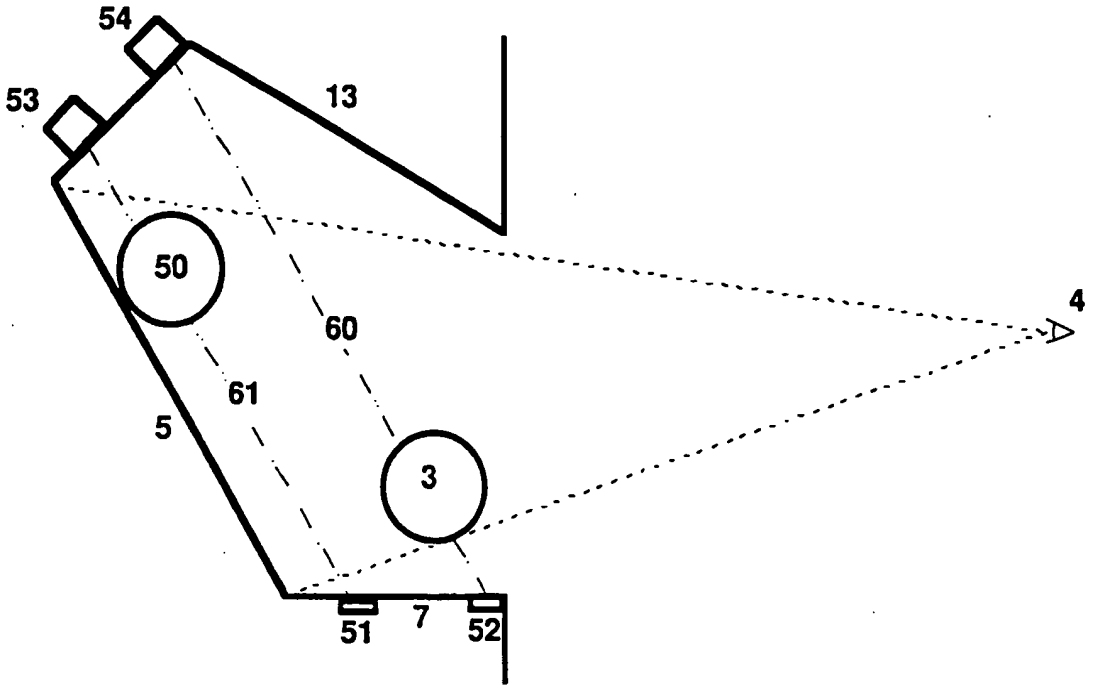
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Fig. 20

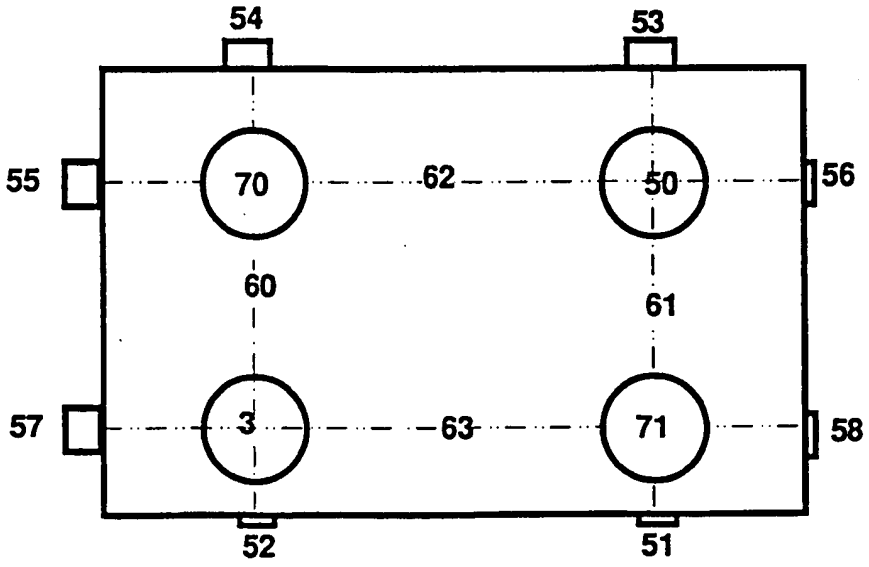
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Fig. 21

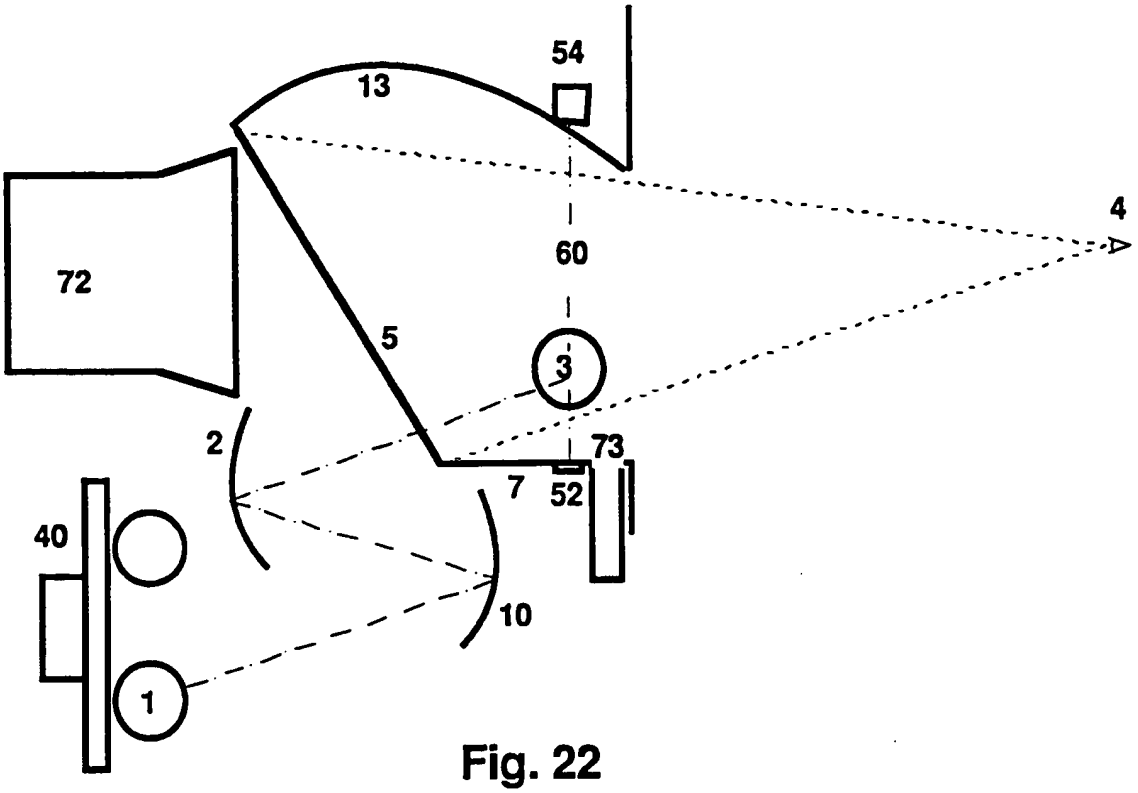

Fig. 22

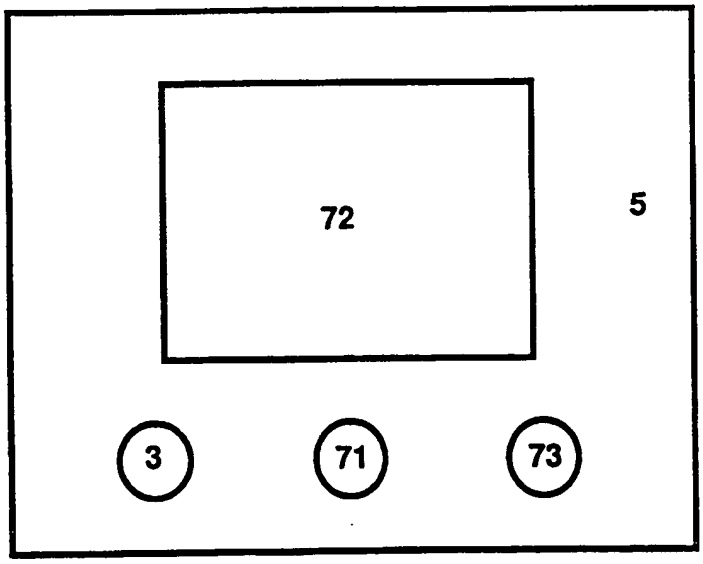

Fig. 23

INTERNATIONAL SEARCH REPORT

Interr al Application No
PCT/GB 96/00123

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02B27/22 G02B27/24 A63F9/22 G03H1/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02B A63F G03H H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US,A,4 671 625 (NOBLE LOWELL A) 9 June 1987 see column 6, line 37 - line 68 see column 7 see column 8, line 1 - line 43 see figures 4,5	1,16 2,3
X A	EP,A,0 310 077 (LETTNER) 5 April 1989 see the whole document	1 2,3,22
A	WO,A,93 15430 (WALT DISNEY PROD) 5 August 1993 see the whole document	1,2,10, 11,16
A	WO,A,89 09423 (LASER 681 S R L) 5 October 1989 see page 6, line 17 - line 37 see figure 7	1,2, 10-13,16

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 May 1996	2.08.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	WARD, S

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INTERNATIONAL SEARCH REPORT

I national application No.
PCT/GB96/00123

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. CLAIMS : 1-30
2. CLAIMS : 31-48

FOR FURTHER INFORMATION PLEASE SEE FORM PCT/ISA/206 MAILED 04.06.96

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-30

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Inter ...al Application No
PCT/GB 96/00123

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4671625	09-06-87	JP-A- 60059317	05-04-85
EP-A-310077	05-04-89	DE-A- 3808406	06-04-89
		DE-U- 8713077	21-01-88
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